Project Area 34.1/2- Tucannon River Stream Habitat Enhancement

Preliminary Basis of Design Report

May 2023

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Project Background

The Columbia Conservation District (CCD) is leading the restoration of project area 34.1/2 on the Tucannon River (River Miles 11.4-12.9). CCD is pursuing restoration throughout the Tucannon River with a focus on addressing ecological concerns and limiting factors identified in the Salmon Recovery Plan for SE Washington (SRSRB, 2011). The Tucannon watershed is an integral piece to the Snake River and Columbia River basins, to support a thriving habitat for all life stages of ESA-listed spring Chinook and summer Steelhead. The primary goal of this project is to restore a healthy, naturally functioning river channel and floodplain by addressing the limiting factors in coordination and cooperation with the Tucannon River Programmatic Project to encourage growth and sustainability for anadromous salmonids in the future.

Problem Statement

Geomorphic processes, floodplain connectivity, and accompanying habitat for native salmonid species within the reach have been influenced by historic land use practices, tree harvest/clearing, and excavation and other bulk earthwork activities at various locations within the 100-year floodplain. These activities have led to limited instream and floodplain habitat complexity, degraded floodplain connectivity and riparian condition, elevated summer water temperatures, and elevated embeddedness all key habitat limiting factors for Chinook and steelhead (Anchor QEA 2011a). This project aims to address many of these factors through stream restoration and habitat enhancement which would lead to natural functioning conditions.

Project Goals and Objectives:

The primary goal of this project is to address the Primary Limiting Factors identified in the Salmon Recovery Plan for SE Washington (SRSRB 2011) and the Tucannon Sub basin Plan (CCD 2004) by restoring to the nearest possible extent a healthy naturally functioning river channel and floodplain. This goal is set within the context of an active production agricultural field and amongst infrastructure supporting those activities.

Goals and Objectives:

Short Term (3 yrs):

- Increase pool frequency and volume > 50% within 3 years
- Increase channel complexity, activate side channels and increase floodplain connection.
- Reduce sediment delivery from the Pataha Creek crossing.
- Address confining features
    - Bridge- Improve channel capacity at the bridge.
    - Levees- Remove levees on the left bank

    - Increase flood frequency and duration on 15 acres of available floodplain from the >5yr interval to <2 yr interval.
- Levees currently are located on the left bank of the Tucannon River and impede floodplain connection at low flows. Examine ways to increase low flow connection to floodplain.

Long Term Objective (3-5 yrs):

- Increase floodplain connectivity and channel complexity.
    - Maintain > 2 key pieces beyond 10 years
    - Anticipated a 50% increase side channels within the first 10 yrs.
    - Connect disconnected low floodplain (<2 yr flow) ~ 15 acres
- Planting to restore a floodplain and upland terrace forest
    - 3,400 trees interstitially planted
- 5 acres of new cover trees planted

Past Studies

The reach of interest for this project extends from river mile 11.4 to river mile 12.9. The land use on the valley floor is productive irrigated agriculture and pasture. Figure 1 shows the general overview of the project area and current land use. The riparian area ii this reach is protected, portions are enrolled in the Conservation Reserve Enhancement Program (CREP), while the remaining riparian area is protected by the private landowner.

In 2011, The Columbia Conservation District partnered with the Bonneville Power Administration, Salmon Recovery Funding Board and the Snake River Salmon Recovery Board to conduct a Geomorphic Assessment (Anchor QEA 2011 April) and Conceptual Restoration Design (Anchor QEA 201 Nov, Anchor QEA 2012) for the entire lower 50 miles of the Tucannon Basin. The project area proposed for restoration was identified in the restoration plan as Project Area 34.1 & Project Area 34.2 (PA-34.1/2) with the recommended restoration actions including; improving floodplain connectivity, removing channel confining features, increasing large wood debris, address excess transport capacity and sediment distribution and protecting existing channel complexity.

Fisheries

The Tucannon supports populations of four threatened species including the Snake River ESU spring Chinook, Snake River fall Chinook, Snake River ESU summer Steelhead, and the Columbia River Bull Trout. All reaches of the Tucannon River are utilized by 3 of the 4 species during one or more life stage annually with fall Chinook being the exception using only the lower river. The lower Snake River spring Chinook is currently only found in the Tucannon River, having been extirpated from Asotin Creek.

The Tucannon River spring Chinook is a sub-population of the Snake River spring Chinook ESU which has been listed as threatened under the Endangered Species Act since 1992, Summer run Steelhead were ESA listed in 1997. Both species and lifecycles are the primary focus of this restoration project. The Tucannon River is the lowest downstream tributary population in the Snake River and is also the lowest elevation drainage where Snake River spring Chinook exist.

Figure 1. Overview of project area from RM 11.4 to 12.9.

The population was in decline throughout the 80's but reached a critical low in the mid 90's when the number of wild adults dipped to as few as three naturally produced individuals. More recently, adult returns to the Tucannon have been steadily increasing as overall habitat conditions improve (WDFW Communication 2015). The current known distribution for spawning and rearing spring Chinook in the Tucannon is from RM 20 upstream to RM 58 based on available information (WDFW Communication 2015). It is anticipated that as conditions improve this boundary will be expanded downstream.

At the drafting of the Snake River Salmon Recovery Plan in 2005, spawning and rearing habitat for Chinook or steelhead was not available below RM 30, but improving stream temperatures and more recently flow, the technical opinion, supported by spawning data (RTT 2013 Communication), is that habitat availability has been extended to at least RM 20 and potentially further downstream in favorable years.

Fish Use in this Project Area

The current fish use for the project reach were detailed in the following passages from the Conceptual Restoration Plan (Anchor QEA, 2011):

[PA 34.1/2] is used for steelhead spawning and rearing but the density of steelhead redds and presence of juveniles is typically low downstream Pataha Creek. Spring Chinook and bull trout use this area during migration periods, perhaps most importantly during outmigration for juveniles. [This area] is important for fall Chinook as its used for spawning and rearing.

Existing Conditions

The existing conditions for the project reach were detailed in the following passages from the Conceptual Restoration Plan (Anchor QEA, 2011):

4.1.1.1 Channel Characterization

Based on air photo and LiDAR interpretation, the mainstem consists of a single-thread channel throughout most of the project area. Levees exist along much of the right bank throughout the entire project area and to a lesser degree along the left bank. These are in place to limit channel migration and flooding into and on the adjacent agricultural lands. This has resulted in incised channel conditions through much of the project area, with limited channel and habitat diversity.

In the downstream extent of the project area, from approximately RM 12.1 to 11.45, the channel appears to be more diverse with good habitat diversity and channel complexity. Side channels are evident in the 2010 air photos near Reach 4 Conceptual Projects Conceptual Restoration Plan Reaches 3 and 4 October 2012 Tucannon River 27 120687-01.01 RM 11.6. The main channel flows along the valley wall throughout a portion of the project area. Pataha Creek is a right bank tributary at approximately RM 12.5. 4.1.1.2.

Floodplain Connectivity

The floodplain connectivity of the reach was provided in the following passages from the Conceptual Restoration Plan (Anchor QEA, 2011):

Floodplain Characterization

Because of the channel confinement through the project area between RM 13.4 and RM 12.5, overbank floodplain areas are limited. In lower extent of the project area, floodplain connectivity is moderate to good, where the lower extent of the project area at RM 11.8 to RM 11.45 is unconfined. Based on aerial photo interpretation, a sparse to moderate stand of riparian trees is located throughout the project area. Some of this vegetation appears to be mature deciduous trees, likely consisting of a mix of alder, cottonwood and lesser extent locust trees (similar to the upstream reaches).

Significant riparian vegetation is lacking along the left bank in areas where the channel abuts the bedrock valley wall. Based on aerial photo interpretation, the condition and type of the understory is indeterminate.

Development of Alternatives

In developing alternatives for restoration of this reach discussions took place between the stakeholders, CCD, landowners, Programmatic Staff, SRSRB Staff and the Regional Technical Team (RTT) to prioritize opportunities, address concerns and identify alternatives. Additionally, Anchor QEA conducted a site visit and presented a memo to provide initial assessment of the conditions of the Tucannon/Pataha confluence and the bridge across the Tucannon River (Anchor QEA, 2022). The three alternatives developed from the process are described below.

Alternative 1- This alternative addresses the project goals and objectives by installing LWD structures in the main channel, side channels and on the floodplain. In this alternative up to 60 LWD structures would be installed to; promote aggradation, increase instream complexity, promote pool formation and increase pool size. The structures will be designed to activate side channels and increase floodplain connection at lower recurrence interval flows.

Additionally, options to increase the capacity of the bridge over the Tucannon river will be explored (e.g. culverts on floodplain, increase bridge height, increase bridge length, etc.), and the Pataha Creek crossing will addressed to reduce sediment introduction. The Pataha Creek crossing improvements will consider an improved crossing or installing a bridge at an upstream location.

All disturbed sites would be replanted with native trees and shrubs and reseeded with a native grass mix.

Alternative 2- This alternative will include the same main stream LWD structures as alternative 1 and would improve floodplain connectivity by removing the existing levees located on the left bank of the Tucannon River. The removal of the existing levees will provide access to 5.3 acres of floodplain. Additional floodplain habitat components including LWD structures and pilot channels may be placed on the floodplain to reduce flood flow velocities, provide complexity and habitat as determined by results from the hydraulic model.

All disturbed sites would be replanted with native trees and shrubs and reseeded with a native grass mix

Alternative 3- This alternative expands upon alternative 2 by installing setback levees to protect existing infrastructure. The location of the levees shown on the plan view drawings are approximate and based on existing topography, landowner preference and desire to maintain production agriculture. Final siting and levee size would be determined during the hydraulic modeling of the reach. Additionally, water surface elevation and velocity information will be utilized to determine the treatments (e.g. side channels, LWD placements, riparian plants) that are planned for the floodplain improvements.

Selection of Preferred Alternative

To begin the process of selecting the preferred alternative a benefit matrix was developed the shows the relative level of benefit each of the alternatives achieves.

Table 1. Alternatives Benefit Matrix

	Alternative 1	Alternative 2	Alternative 3
Increase Pool frequency and volume	+++	+++	+++
Increase channel complexity	+++	+++	+++
Activate side channels	++	+++	+++
Increase floodplain connection	+	+++	++
Reduce sediment delivery from Pataha Creek crossing	+++	+++	+++
Address confining features	+	+++	+++
Increase flood frequency and duration.	+	+++	++

\+ - Lowest benefit achieved

++ - Moderate level of benefit achieved

+++ - Highest level of benefit achieved

Cost Estimate

A preliminary cost estimate for the project was developed and is shown below. The cost estimate reflects the recent costs associated with similar projects in the area.

Of specific note-
The Access Crossing improvements line item is the assumed cost of completing improvements to the bridge over the Tucannon River and the Pataha Creek crossing. This cost was determined based on installing floodplain culverts on the south end of the Tucannon bridge and improving the existing crossing of Pataha Creek or installing a bridge at an upstream location that is available at minimum charge. This line item is a placeholder until further information is developed in the preliminary design stage.

Construction						
Category (choose one)	**Task Description**	**Qty**	**Rate**	**Alternative 1**	**Alternative 2**	**Alternative 3**
Mobilization	*Mobilization/Demobilizati*	1.00	$ 22,000.00	$ 22,000	$ 22,000	$ 22,000
Plans	*Water/TESC/SPCC*	1.00	$ 4,500.00	$ 4,500	$ 4,500	$ 4,500
Site Prep and TESC Measures	*Fence, silt/livestock, site recovery, misc. materials*	1.00	$ 27,000.00	$ 27,000	$ 27,000	$ 27,000
Site Specific LWD Structures	*Materials/Construction*	45.00	$ 16,000.00	$ 720,000	$ 720,000	$ 720,000
Multi LWD Structures	*Materials/Construction*	2.00	$ 37,200.00	$ 74,400	$ 74,400	$ 74,400
Apex LWD Structure	*Materials/Construction*	10.00	$ 27,600.00	$ 276,000	$ 276,000	$ 276,000
Floodplain LWD Structure	*Materials/Construction*	4.00	$ 5,700.00	$ 22,800	$ 22,800	$ 22,800
Care of Water Work	*Temp. Flow diversion/dewatering*	2.00	$ 2,200.00	$ 4,400	$ 4,400	$ 4,400
Materials Revegetation	*Plants Materials/grass seed*	1.00	$ 15,000.00	$ 15,000	$ 15,000	$ 15,000
Access Crossing Improvements	*Materials/Construction*	1.00	$ 170,000.00	$ 170,000	$ 170,000	$ 170,000
Off-set Levee Installation	*Materials/Construction*	1.00	$ 80,000.00	$ -	$ 10,000	$ 80,000
Misc. Materials	*Re-bar, anchors, rope*	1.00	$ 10,000.00	$ 10,000	$ 10,000	$ 10,000
		Sub-Total	$ -	$ 1,346,100	$ 1,356,100	$ 1,426,100
Sals Tax @.086		0.09	$ 115,764.60	$ 115,765	$ 116,625	$ 122,645
		-	$ -	$ -	$ -	$ -
Construction mgmt. Oversite	*Engineer*	1.00	$ 1.00	$ 31,500	$ 31,500	$ 31,500
Permits	*Permits*	1.00	$ 2,300.00	$ 2,300	$ 2,300	$ 2,300
Cultural Resources	*Cultural Resources*	1.00	$ 13,000.00	$ 13,000	$ 13,000	$ 13,000
Revegetation	*Planting/WCC/Technician*	1.00	$ 8,000.00	$ 8,000	$ 8,000	$ 8,000
			STotal	$ 1,516,665	$ 1,527,525	$ 1,603,545

Administrative, Architechtural & Engineering						
Category	**Task Description**	**Qty**	**Rate**			
Administrative, Architechtural & Engi	*Contract inspection & Mngmt.*			$ 54,572.00	$ 54,572.00	$ 54,572.00
			STotal	$ 54,572	$ 54,572	$ 54,572
			GTOTAL	$ 1,571,237	$ 1,582,097	$ 1,658,117

To proceed with a selection of the alternative the pros and cons of each were reviewed and summarized below.

Pros and Cons-

Alternative 1- This alternative is the lowest cost option that provides immediate benefit. The addition of the LWD structures will reduce velocities in and around the structures, will create and maintain pool habitat and will promote sediment sorting and deposition. This alterantive is expected to increase floodplain connectivity but not to the extent of alternatives 2 & 3. Hydraulic modeling of the LWD structures will provide information used to determine the final structure type and placement.

Alternative 2- Provides the same benefits as alternative 1 and with the removal of the levees it provides for improved floodplain connection to 5.3 acres of floodplain. This is expected to have greater impacts on the instream channel dynamics as the river will have access to the floodplain. Additional floodplain LWD structures and/or pilot channels will be explored after the hydraulic modeling is completed. The drawback, from the stakeholders' position, is that it does not provide protection to the existing infrastructure. With the addition of the levee removal the costs of Alternative 2 are greater that Alternative 1.

Alternative 3- Provides the same benefits as Alternatives 1 and 2 and provides protection of the existing infrastructure with the addition of the existing levee. With the addition of constructing new levees the costs of Alternative 3 are greater than alternatives 1 and 2.

Stakeholder Discussion

Over several months, the alternatives were discussed amongst the stakeholders. In discussions, there were concern about impacts of the project on the bridge. As it is the only crossing to get to agricultural land, shops and a home, the landowners and stakeholders want to ensure that the project does not negatively impact the bridge.

Another concern was future flooding impacting the road and pump sites that were washed out in past flood events. The landowner was also concerned with removing the work that was done after the 1996/97 flood events that held during the 2020 flood event. The landowner was comfortable with structures as long as they were not going to endanger the bridge.

Selection of the Preferred Alternative

After reviewing the information with the stakeholders it was determined that Alternative 3 was the preferred alternative.

Preferred Alternative Update- April 2023

After further discussions with the landowner, it was determined that Alternative 1 with the addition of a high flow relief channel would be the preferred alternative. The plan set included in Appendix A details the planned work.

With the decision of the preferred alternative the project design was completed. The primary project features are listed below.

List of Primary Project Features

- LWD placements (73) --varying in size from single log placements to 7 member ELJs.
- Improvement to access road crossing(s).

LWD Structure Description

The LWD structures used in the plan are detailed in the attached drawing set. These structures have been used on similar projects over the past years on the Tucannon River and have shown to be effective in creating the biological and geomorphic benefits desired. A description of the large woody debris (LWD) structures are included below.

APEX LWD

The Apex LWD structure is comprised of 7 LWD members with rootballs, it is intended to promote and/or create an existing center bar by reducing velocities in and around the structure. The reduction in velocities within the the structure provide refuge. These structures also create and maintain pool habitat on the margins of the structure which provide complex pool habitat. Additionally, the structures promote sediment sorting and deposition. The structure is connected at the log crossings and piles are added to retain the structure. The structure is intended to collect and shed naturally occurring woody materials that are moving within the system.

Floodplain Roughness LWD

The Floodplain Roughness LWD structure is comprised of a single log with attached rootball, it is intended to increase the complexity of the floodplain by decreasing velocities in the immediate vicinity of the structure. This will promote the sorting and retention of mobilized materials and provide a low velocity refuge. It is typically installed in areas with minimal riparian vegetation and enhances the retention of mobile debris.

TRI LWD

The TRI LWD structure is intended to mimic a small debris jam and is comprised of multiple logs with rootwads attached and log poles. LWD members are placed around the main member to provide for the retention of mobile wood, increase the complexity and to provide for ballasting of the structure. These structures are connected at the log crossings and piles are added to retain the structure. Small wood materials (slash) is added to the structure to increase the complexity. The structure is intended to collect and shed naturally occurring woody materials that are moving within the system and will provide pool habitat, high flow refuge, escapement cover and will promote local deposition.

LWD Structure Performance

The LWD structures are intended to mimic natural debris jams, collecting and shedding naturally occurring woody materials that are moving within the system. As such, the structures are temporary in nature and are expected to have a life expectancy of 5- 10 years. The primary driver of the expected life is the decomposition of the LWD materials used in the structure.

LWD Structure Risk Assessment

The project was reviewed for potential risks associated with the installation of the structures. The risk to the agricultural production ground was also examined and the primary risk was found to be to the production field located along the project reach. After discussing with the landowner, it was determined that the risks associated with the project are acceptable.

Project Design

The design of the project included the development of the hydrology for the site, hydraulic modelling and LWD structure stability analysis. A description of the analysis is included below.

Hydrology

Hydrology for the project reach was investigated and is documented below. Discharge data in the Tucannon River at RM 7.9 is available from USGS gage No. 13344500 located on river right, 180 feet downstream of the Smith Hollow Road bridge. The drainage basin upstream of the gage is 431 square miles. Annual discharge statistics are available beginning in water year (WY) 1915 through 2019. Three significant data gaps exist in the record from WY 1918 to 1928, 1932 to 1958, and from 1991 to 1994. The largest recorded flood is 7980 cfs on December 12, 1964. A total of 63 water years of annual discharge statistics are available (Figure 1).

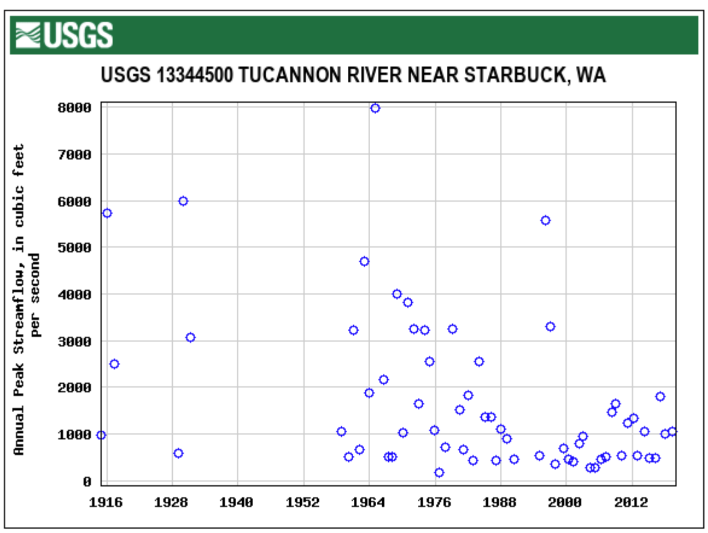

FIGURE 2. ANNUAL PEAK STREAMFLOW FROM USGS GAGE NO. 13344500

The USGS StreamStats application was used to delineate drainage basins and compare estimated peak flow statistics at the location of USGS gage No. 13344500 at Tucannon River Mile 7.9 and at the downstream end of the project reach at Tucannon RM 11.4 (Figure 2).

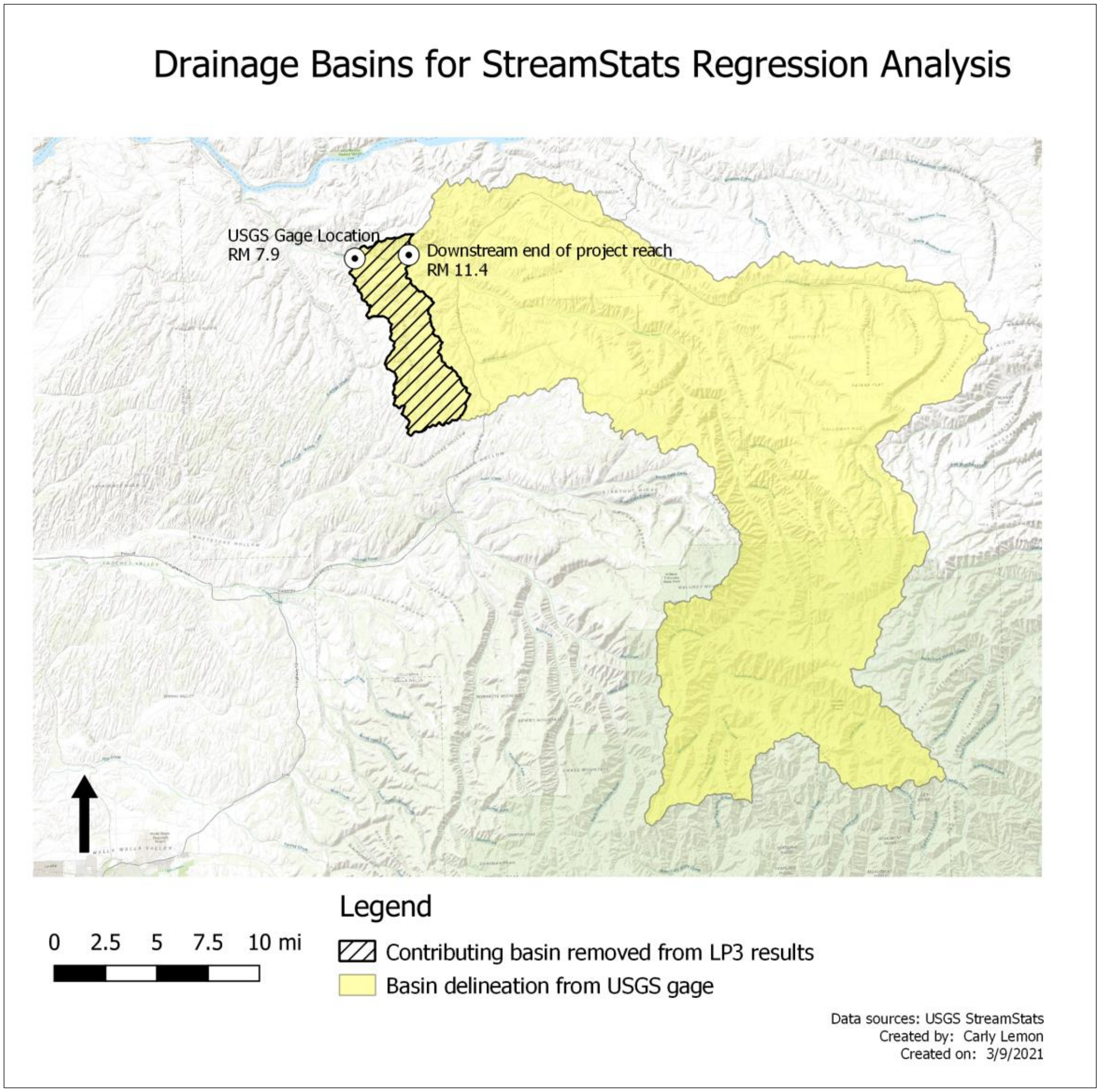

FIGURE 3. BASIN DELINEATIONS FROM STREAMSTATS

Hydrologic Analysis:

The log-Pearson type III analysis method is the standard used by U.S. federal agencies for flood analysis as described in Bulletin 17b from the Interagency Advisory Committee on Water Data. Qualification codes for the annual discharge data were reviewed prior to analysis. USGS qualification codes indicate that maximum annual discharge may be underestimated for water years 1988, 1995, 1999 and 2004; these data were not removed from the dataset.

A flood magnitude and frequency analysis for the Tucannon River at the downstream end of the project reach at RM 11.4 was conducted using the following process:

1. Calculate a log-Pearson type III (LP3) frequency distribution using data from USGS Gage No. 13344500.
2. Perform a regression analysis using the USGS StreamStats Web application to obtain peak flow estimates for the same recurrence intervals as were calculated with the LP3 analysis at the USGS gage location.
3. Perform a regression analysis using the USGS streamstats Web application to obtain peak flow estimates at the downstream end of the project reach at Tucannon River RM 11.4.
4. Adjust the LP3 discharge results by subtracting the difference between the StreamStats results at RM 7.9 and 11.4.

Regression analysis using regional data was performed to estimate the contribution of the 25.1 square miles of drainage basin area between RM 11.4 and RM 7.9 as shown by the cross-hatched symbology in Figure 2. Regression analysis results are not available from the StreamStats application for a 1-year return interval. The 1-year LP3 results were not adjusted to account for the 25.1 square mile contribution area between the USGS gage and the downstream end of the project reach at RM 11.4.

Monthly mean discharge data is available from the USGS gage for the period of 10/1/1914 through 4/30/2020. The average of monthly mean discharge over the period of record is shown in Table 1. Average monthly mean flows represent a “typical” monthly discharge. A typical average winter discharge was calculated by taking the average of mean monthly mean discharge for January through May. The typical winter discharge of 262 cfs was calculated for the USGS gage location and was not adjusted to account for the 25.1 square mile contribution area between the USGS gage and the downstream end of the project reach at RM 11.4.

Mean of Monthly Mean Discharge (cfs)	(Calculation Period: 1914-10-01 to 2020-04-30)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	206	251	259	293	300	199	84	61	70	84	108	155
Winter average (Jan - May)					**262 cfs**							

TABLE 1. MEAN OF MONTHLY MEAN DISCHARGE

Results:

Estimates of flood flow discharge using LP3 analysis for the 1, 2, 5 and 10-year events are lower than the regression estimates from StreamStats. The 25-year flood estimates using LP3 and regression analysis are nearly equal. The 50 and 100-year flood estimates from the LP3 analysis are higher than the regression analysis results. The largest difference between results from the LP3 and regression analysis methods is for the 2-year return frequency where regression results are approximately 1.5 times higher than the LP3 results.

Final flood frequency results are provided below in Table 2. The results for the 2, 5, 10, 25, 50, and 100-year flood events are LP3 results that have been adjusted for the reduced basin area at the downstream end of the project reach (Figure 2). Final flood frequency results for the 1-year flood and typical winter discharge have not been adjusted for reduced basin area.

Figure 3 below shows the record of instantaneous daily discharge for water years 2010 through 2020. The following are "ground-truthing" observations about the LP3 analysis results in comparison to the 10-year period of record shown in Figure 3.

- Instantaneous daily discharge (shown in blue) exceeded the 1-year (99% probability) flood in all ten water years.
- Instantaneous daily discharge exceeded the 2-year (50% probability) flood in four out of ten water years.
- Instantaneous daily discharge exceeded the 5-year (25% probability) flood in one out of ten water years. This flood, in February 2020, nearly exceeded the 10-year (10% probability) flood as well.

Return Interval (year)	River mile 7.9 USGS gage near Starbuck (LP3 results, cfs)	River mile 7.9 USGS gage near Starbuck (regression results, cfs)	River mile 11.4 downstream end of project reach (regression results, cfs)	Adjustment to LP3 results (RM 7.9-RM 11.4 regression results, cfs)	Final Flow Results (cfs)
Q1	172	NA*	NA*	N/A*	**172**
Q2	1099	1660	1620	40	**1059**
Q5	2378	3040	2940	100	**2278**
Q10	3639	4210	4050	160	**3479**
Q25	5830	5950	5710	240	**5590**
Q50	7980	7560	7230	330	**7650**
Q100	10650	9300	8870	430	**10220**
			Winter average (January - May)		**262**

TABLE 2. FINAL FLOW RESULTS
*STREAMSTATS REGRESSION NOT AVAILABLE FOR 1-YEAR FLOOD FREQUENCY

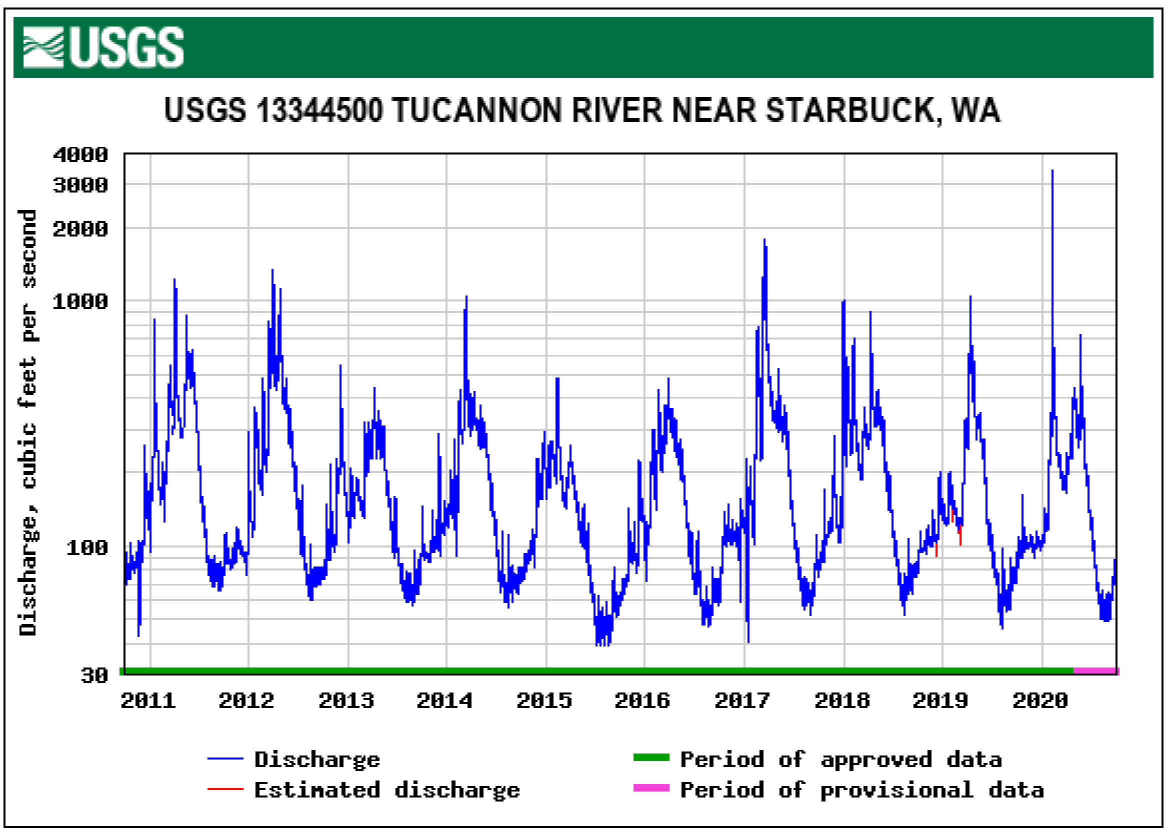

FIGURE 4 DAILY DISCHARGE WY2010 - WY2020

Hydraulic Model

The hydraulics of the project reach were examined using HEC RAS (v6.0). The model was developed to analyze water surface elevations, velocities and shear stress for the return flows described in the hydrology section. The development of the model is described below.

Model Summary

HEC RAS is a model developed by the US ARMY Corps of Engineers to perform one dimensional, two dimensional or combined hydraulic calculations for a full network of natural and constructed channels. For this project, a 2 dimensional unsteady flow model was developed to model the impacts of adding LWD structure to the reach as shown in the attached drawing set.

Model Extents

The model was developed for the project from river mile 11.4 to 12.9 and spans across the valley, extending well above the 100 YR flood elevations.

Model Terrain

The existing conditions model terrain was created from a LIDAR data set acquired by NV5 Geospatial for the Confederated Tribes of the Umatilla Indian Reservation in 2020. The profile and cross-sections for the project reach are included in Appendix B.

Model Geometry

The 2d model geometry was created using a mesh spacing of 10 feet by 10 feet.

Model Roughness

The existing conditions model roughness were set based on Table 3. For the addition of the LWD structures to the proposed conditions the model roughness at the location of the proposed structures was increased as shown in the table.

Table 3: Roughness coefficients used in the 2D model

Region description	Manning's n value
River channel; cobble/gravel bed with some boulders	0.035
Riparian areas; brush, trees and other dense vegetation	1.0
Farm fields and orchards; field crops	0.02
Proposed large wood structures: perimeter and top	0.12
Floodplain; cobble areas very few trees or shrubs	0.04
Forest	0.08
Shrub/scrub	0.07

Model Discharges

The model was ran for all of the flows of interest listed in Table 2. For each return flow a hydrograph was created for a 100 hour time interval. The hydrograph was set to a low flow condition and ramped up to the maximum discharge for that return flow. The maximum discharge was maintained for the remainder of the model time.

Model Boundary Conditions

The boundary conditions for the upstream and downstream boundaries of the model were set. For the upstream boundary, the hydrograph was routed through the boundary and was set to spread the flow across the boundary based on the normal depth. The downstream boundary condition was also set to allow the flow to spread across the terrain using the normal depth.

Model Output

The results of the model were reviewed using RASMAPPER , a graphical interface included in HEC RAS, to investigate the inundation, velocity, depth and shear stress throughout the reach for the existing and proposed conditions. The results were exported to ARCMAP to generate figures for inclusion in the report. Selected results are shown in Appendix C.

Discussion of Results

The model results, shown in Appendix C, show that the project will achieve the desired results. Specifically, the installation of the LWD structures will decrease water velocity, which will increase the floodplain connectivity at all flows. Additionally, the shear stress results show that pools will be formed and the velocity distribution map indicate greater extents of low velocity water.

LWD Structure Stability

To determine the anchoring requirements of the LWD structures a force balance analysis, following the guidelines in "Large Woody Material Risk Based Design Guidelines" (Knutson et. al. 2014) and the "National Large Wood Manual" (USBR/ERDC 2016), was completed.

Factors of Safety

The project setting is highly productive agricultural ground. Following the guidelines in Knustson et al., 2014 the project would be rated as low for public safety risk and moderate for property damage risk. Therefore, safety factors of 1.5 for sliding, 1.75 for buoyancy and 1.5 for rotation and overturning should be achieved.

Table 4. Minimum Recommended Factors of Safety (Knutson et al, 2014)

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	$FOS_{sliding}$	$FOS_{bouyancy}$	$FOS_{rotation}$ $FOS_{overturning}$
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

Each of the different structure types were analyzed to verify the stability of the structure. The modeled velocity from HEC RAS was used to complete the stability analysis of the LWD structures. Typical calculation sheets are shown in figures 5, 6 and 7.

Ballast/Anchoring Considerations

During site visits to the project reach the project team discussed the anchoring options for the structures. The bed/bank composition was the primary focus with the availability of mature riparian trees for potential anchoring options also considered. It was found that the majority of the reach has gravel substrate. Mature trees were present and could be utilized to anchor bank attached LWD structures. From our observations we estimated that the majority of the structures could be anchored with driven piles, while the remainder of the structures will use a combination of rock ballast, burial of members and connections to mature trees.

At the time of construction, each structure will be evaluated by the project team to determine the type of anchoring that will be used to best meet the desired goal of the structure. Driven piles will be the primary anchoring method, where driven piles are not feasible, anchoring of the structures will be accomplished with the combination of ballast rock, burial of members and the use of existing trees for support.

Structural Stability Calculations for Large Woody Material

Calculates vertical (buoyancy) and horizontal (sliding) forces; includes factor of safety calculations.

Designed By:	L. Horning
Checked By:	L. Horning
Project:	PA34 Tucannon
Date:	5/2/2023
Station Location/Number:	Structure #1
Structure Type:	Apex structure

Assumptions
All overburden soil, anchors, and logs will be fully submerged during the 100-year flood.
Lift forces are typically neglected since it is assumed that scour and deposition quickly reshape the local topography (Wallerstein et al. 2001).
All forces calculated for structure as a single unit; individual log members are pinned togther

Log Properties and Site Characteristics		*Units*
Volume of backfill ballast =	0.00	ft^3
Specific weight of backfill material =	0.00	lb/ft^3
Specific weight of water =	62.40	lb/ft^3
Mechanical anchor pullout capacity (0 if none used) =	0.00	lb
Total volume of LWM =	593.70	ft^3
Specific weight of LWM =	29.95	lb/ft^3
Lift coefficient (0 if lift forces are neglected) =	0.00	unitless
Area of LWM perpindicular to flow =	238.61	ft^2
Porosity coefficient for area of LWM =	0.20	unitless
Approach velocity at design event (100-year flood) =	8.50	ft/sec
Accelation due to gravity =	32.17	ft/sec^2
Coefficient of friction (approaches 0 as structure becomes fully submerged =	0.00	unitless
Coefficient of passive earth pressure =	4.60	unitless
Horizontal resistance from driven piles (0 if no piles are used) =	37058.96	lb
Drag coefficient =	1.00	unitless

Vertical Forces - resistance to flotation		*Units*
F_{soil} - soil and rock ballast force	0	lb
F_{AV} - mechanical anchor pullout force	57370	lb
F_B - buoyant force	-19264	lb
F_L - lift force	0	lb
F_v - vertical stability	38106	lb
Safety factor for vertical stability	3.0	unitless

Horizontal Forces - resistance to sliding		*Units*
F_F - friction force	0	lb
F_p - passive soil pressure force	0	lb
F_{AH} - mechanical anchors and driven pile forces	37059	lb
F_d - drag force	-13374	lb
F_H - horizontal stability	23685	lb
Safety factor for horizontal stability	2.8	unitless

Figure 5. APEX LWD Stability Calculations.

Structural Stability Calculations for Large Woody Material	
Calculates vertical (buoyancy) and horizontal (sliding) forces; includes factor of safety calculations.	
Designed By:	L. Horning
Checked By:	L. Horning
Project:	PA34 Tucannon
Date:	5/2/2023
Station Location/Number:	Structure #4
Structure Type:	Floodplain structure

Assumptions
All overburden soil, anchors, and logs will be fully submerged during the 100-year flood.
Lift forces are typically neglected since it is assumed that scour and deposition quickly reshape the local topography (Wallerstein et al. 2001).
All forces calculated for structure as a single unit; individual log members are pinned togther

Log Properties and Site Characteristics		*Units*
Volume of backfill ballast =	180.00	ft^3
Specific weight of backfill material =	132.00	lb/ft^3
Specific weight of water =	62.40	lb/ft^3
Mechanical anchor pullout capacity (0 if none used) =	0.00	lb
Number of LWD members=	3.00	members
Total volume of LWM =	254.44	ft^3
Specific weight of LWM =	29.95	lb/ft^3
Lift coefficient (0 if lift forces are neglected) =	0.00	unitless
Area of LWM perpindicular to flow =	169.63	ft^2
Porosity coefficient for area of LWM =	0.20	unitless
Approach velocity at design event (100-year flood) =	5.00	ft/sec
Accelation due to gravity =	32.17	ft/sec^2
Coefficient of friction (approaches 0 as structure becomes fully submerged) =	0.00	unitless
Coefficient of passive earth pressure =	4.60	unitless
Horizontal resistance from driven piles (0 if no piles are used) =	3047.60	lb
Drag coefficient =	1.00	unitless

Vertical Forces - resistance to flotation		*Units*
F_{soil} - soil and rock ballast force	12528	lb
$F_{A,V}$ - mechanical anchor pullout force	4591	lb
F_B - buoyant force	-8256	lb
F_L - lift force	0	lb
F_v - vertical stability	8863	lb
Safety factor for vertical stability	2.1	unitless

Horizontal Forces - resistance to sliding		*Units*
F_F - friction force	0	lb
F_P - passive soil pressure force	5762	lb
$F_{A,H}$ - mechanical anchors and driven pile forces	3048	lb
F_d - drag force	-3290	lb
F_H - horizontal stability	5519	lb
Safety factor for horizontal stability	2.7	unitless

Figure 6. FP LWD Stability calculations.

Structural Stability Calculations for Large Woody Material	
Calculates vertical (buoyancy) and horizontal (sliding) forces; includes factor of safety calculations.	
Designed By:	L. Horning
Checked By:	L. Horning
Project:	PA34 Tucannon
Date:	5/2/2023
Station Location/Number:	TRI LWD
Structure Type:	in-channel tri structure

Assumptions
All overburden soil, anchors, and logs will be fully submerged during the 100-year flood.
Lift forces are typically neglected since it is assumed that scour and deposition quickly reshape the local topography (Wallerstein et al. 2001).
All forces calculated for structure as a single unit; individual log members are pinned togther

Log Properties and Site Characteristics		*Units*
Volume of backfill ballast =	0.00	ft^3
Specific weight of backfill material =	0.00	lb/ft^3
Specific weight of water =	62.40	lb/ft^3
Mechanical anchor pullout capacity (0 if none used) =	0.00	lb
Number of LWD Members=	5	members
Total volume of LWM =	378.08	ft^3
Specific weight of LWM =	29.95	lb/ft^3
Lift coefficient (0 if lift forces are neglected) =	0.00	unitless
Area of LWM perpindicular to flow =	138.72	ft^2
Porosity coefficient for area of LWM =	0.20	unitless
Approach velocity at design event (100-year flood) =	8.50	ft/sec
Accelation due to gravity =	32.17	ft/sec^2
Coefficient of friction (approaches 0 as structure becomes fully submerged =	0.00	unitless
Coefficient of passive earth pressure =	4.60	unitless
Horizontal resistance from driven piles (0 if no piles are used) =	20048.34	lb
Drag coefficient =	1.00	unitless

Vertical Forces - resistance to flotation		*Units*
F_{soil} - soil and rock ballast force	0	lb
$F_{A,V}$ - mechanical anchor pullout force	32919	lb
F_B - buoyant force	-12268	lb
F_L - lift force	0	lb
F_V - vertical stability	20651	lb
Safety factor for vertical stability	2.7	unitless

Horizontal Forces - resistance to sliding		*Units*
F_F - friction force	0	lb
F_P - passive soil pressure force	0	lb
$F_{A,H}$ - mechanical anchors and driven pile forces	20048	lb
F_d - drag force	-7775	lb
F_H - horizontal stability	12273	lb
Safety factor for horizontal stability	2.6	unitless

Figure 7. TRI LWD Stability Calculations.

Scour

Scour around all of the structures is anticipated. The Tri LWD and APEX structures are flexible in nature and are anchored in such a manner that individual LWD members may shift during high flow/scour events but they will remain intact and functioning.

Best Management Practices

Control of Surface Erosion

Surface erosion control during construction is an important turbidity control measure for the project. Removal of vegetation may temporarily leave areas exposed and vulnerable to erosion before re-establishment of vegetation. Silt fencing around the perimeter of areas where vegetation is removed is recommended to capture sediment and delineate the construction disturbance limits. During project area decommissioning, straw mulch should be placed to minimize erosion of materials as vegetation is established. Silt fencing should be removed by hand once temporary surface erosion control measures are in place or vegetation is established in the disturbed areas.

Control of Water on the Project

Water control during construction is the most critical turbidity control measure for the project. Installation of many project components will require excavation below the water table, and turbid water will be generated. The following section provides a brief description of the recommended water control procedures for project structure requiring significant water control. However, the contractor will be responsible for developing the final water control plan. Additionally, the contractor will be responsible for dewatering the excavations as required for constructability and pumping water to a location suitable for natural infiltration as approved by the engineer. The contractor will provide sufficient equipment to accommodate changes to the water control plan required by project area conditions during construction as directed by the engineer. During construction, measures will be employed to isolate work areas from active channel flows. The Contractor will complete a Care of Water Plan that will detail the isolation locations, methods and techniques.

References:

Anchor QEA, LLC. 2021. Tucannon Basin Habitat Restoration & Geomorphic Assessment & Restoration Prioritization. Prepared for Columbia Conservation District, Dayton WA. By Anchor QEA Bellingham WA.
https://paluut.ctuir.org/services/uploads/P/2229/S/2259/Tucannon_2021_FINAL_plan_and_appendices_2021-01-26.pdf

Anchor QEA, LLC. 2012. Integrated Species Restoration Prioritization Tucannon River. Prepared for the Columbia Conservation District and Snake River Salmon Recovery Board, Dayton WA. Anchor QEA Bellingham, WA November 2012.

Anchor QEA, 2012. Conceptual Restoration Plan, Reach 5 Tucannon River. October, 2012

Anchor QEA, LLC. April, 2011. Tucannon River Geomorphic Assessment and Habitat Restoration Study. Prepared for Columbia Conservation District, Dayton WA. By Anchor QEA Bellingham WA.

Arcement G and V Schneider. 1989. Guide for selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains. United States Geological Survey Water-Supply Paper 2339. Prepared in cooperation with the US Department of Transportation and Federal Highway Administration.

Beechie, T. J., and T. H. Sibley. 1997. Relationships between Channel Characteristics, Woody Debris, and Fish Habitat in Northwestern Washington Streams. Transactions of the American Fisheries Society 126(2):217–229
Brierley, G., and K. Fryirs. 2005. Geomorphology and River Management. Blackwell Publishing.

CCD, 1997. Tucannon River model Watershed Plan. Columbia Conservation District. July,1997
Hooper, L., and J. A. Hubbart. 2016. A Rapid Physical Habitat Assessment of Wadeable Streams for Mixed-Land-Use Watersheds. Hydrology 3(4):37.

Cram, J. M., C. E. Torgersen, R. S. Klett, G. R. Pess, D. May, T. N. Pearsons, and A. H. Dittman. 2017. Spatial Variability of Chinook Salmon Spawning Distribution and Habitat Preferences. Transactions of the American Fisheries Society.

Cienciala, P., and M. A. Hassan. 2013. Linking spatial patterns of bed surface texture, bed mobility, and channel hydraulics in a mountain stream to potential spawning substrate for small resident trout. Geomorphology 197:96–107.

Doll, B., G. Jennings, J. Spooner, D. Penrose, J. Usset, J. Blackwell, and M. Fernandez. 2016. Can Rapid Assessments Predict the Biotic Condition of Restored Streams? Water 8(4):143.

Fox, M., and S. Bolton. 2007. A Regional and Geomorphic Reference for Quantities and Volumes of Instream Wood in Unmanaged Forested Basins of Washington State. North American Journal of Fisheries Management 27(1):342–359.

Gurnell, A. M., M. Rinaldi, B. Belletti, S. Bizzi, B. Blamauer, G. Braca, A. D. Buijse, M. Bussettini, B. Camenen, F. Comiti, L. Demarchi, D. G. de Jalón, M. G. del Tánago, R. C. Grabowski, I. D. M. Gunn, H. Habersack, D. Hendriks, A. J. Henshaw, M. Klösch, B. Lastoria, A. Latapie, P. Marcinkowski, V. Martínez-Fernández, E. Mosselman, J. O. Mountford, L. Nardi, T. Okruszko, M. T. O'Hare, M. Palma, C. Percopo, N. Surian, W. van de Bund, C. Weissteiner, and L. Ziliani. 2016. A multi-scale hierarchical framework for developing understanding of river behaviour to support river management. Aquatic Sciences 78(1):1–16.

Hausner, M. B., J. L. Huntington, C. Nash, C. Morton, D. J. McEvoy, D. S. Pilliod, K. C. Hegewisch, B. Daudert, J. T. Abatzoglou, and G. Grant. 2018. Assessing the effectiveness of riparian restoration projects using Landsat and precipitation data from the cloud-computing application ClimateEngine.org. Ecological Engineering 120:432–440. Elsevier, Amsterdam.
Knutson and Fealko. 2014. *Large Woody Material - Risk Based Design Guidelines*. U.S. Department of the Interior Bureau of Reclamation Pacific Northwest Region & Technical Services. Boise, Idaho. September 2014. Online: http://www.usbr.gov/pn//fcrps/documents/lwm.pdf

Interagency Advisory Committee on Water Data, 1982, Guidelines for determining flood-flow frequency: Bulletin 17B of the Hydrology Subcommittee, Office of Water Data Coordination, U.S. Geological Survey, Reston, Va., 183 p. Online linkage: http://water.usgs.gov/osw/bulletin17b/bulletin_17B.html.

Ligon, F. K., R. J. Nakamoto, B. C. Harvey, and P. F. Baker. 2016. Use of streambed substrate as refuge by steelhead or rainbow trout Oncorhynchus mykiss during simulated freshets. Journal of Fish Biology 88(4):1475–1485.

Mossop, B., and M. J. Bradford. 2006. Using thalweg profiling to assess and monitor juvenile salmon (Oncorhynchus spp.) habitat in small streams. Canadian Journal of Fisheries and Aquatic Sciences 63(7):1515–1525.

Monitoring Location 13344500, Tucannon River Near Starbuck, Washington. Accessed March 2021. Available at: https://waterdata.usgs.gov/monitoring-location/13344500/.

Rosgen, D. 1994. A Classification of Natural Rivers. Catena 22(3):169–199.
Seixas, G. B., T. J. Beechie, C. Fogel, and P. M. Kiffney. 2018. Historical and Future Stream Temperature Change Predicted by a Lidar-Based Assessment of Riparian Condition and Channel Width. JAWRA Journal of the American Water Resources Association 54(4):974–991.

U.S. Bureau of Reclamation (USBR) and U.S. Army Engineer Research and Development Center (ERDC). 2016. National Large Wood Manual: Assessment, Planning, Design, and Maintenance of Large Wood in Fluvial Ecosystems: Restoring Process, Function, and Structure. 628 pages + Appendix. www.usbr.gov/pn/ January 2016.

U.S. Geological Survey, 2016, The StreamStats program, online at http://streamstats.usgs.gov.

United States Army Corps of Engineers. 2016. River Analysis System, HEC-RAS Version 6.2 Approved for Public Release September 2016.

Watershed Sciences 2010. LiDAR Remote Sensing Date Collection: Tucannon River, Tucannon Headwaters, and Cummins Creek, WA. 517 SW 2nd St Suite 400 Corvallis, OR

Appendix A – Drawing Sets

---- See Attachment

Appendix B- Reach Profile/Cross-Section

----- See Attachment

Appendix C. Hydraulic Model Results

-----see Attachment